Changes and Challenges in the Software Engineering Laboratory

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Background

Since 1976, the Software Engineering Laboratory (SEL) has been dedicated to understanding and improving the way in which one NASA organization, the Flight Dynamics Division (FDD), develops, maintains, and manages complex flight dynamics systems. The SEL is composed of three member organizations: NASA/GSFC, the University of Maryland, and Computer Sciences Corporation. During the past 18 years, the SEL's overall goal has remained the same: to improve the FDD's software products and processes in a measured manner. This requires that each development and maintenance effort be viewed, in part, as a SEL experiment which examines a specific technology or builds a model of interest for use on subsequent efforts. The SEL has undertaken many technology studies while developing operational support systems for numerous NASA spacecraft missions.

Software Improvement Approach

The SEL's basic approach toward software process improvement is to first understand and characterize the process and product as they exist to establish a local baseline. Only then can new technologies be introduced and assessed (phase two) with regard to both process changes and product impacts. Typically, several studies/assessments are in progress at any one time, each with a duration of approximately 1–3 years. The third phase of the SEL approach (packaging) synthesizes the results of the first two phases and feeds them back into the cycle to assist software development on subsequent projects. Packages include products such as process tailoring guidelines, training courses, tools, and guidebooks. The SEL's process improvement approach has proven very effective in the FDD, with the organization's software product showing substantial improvements in error rates, reuse, and cycle time; and it has been recognized throughout the software engineering community. In 1994, the SEL received *the IEEE Computer Society Award for Software Process Achievement* and a *Federal Technology Leadership Award* for its application of these innovative concepts in a production environment.

SEL Operational Changes

The SEL's development and maintenance environments differ somewhat in their characteristics. On development efforts, the languages and processors used reflect a

movement toward workstation-based systems: languages are FORTRAN (70%), Ada (15%), and C (15%) spread over 65% mainframe systems and 35% workstation systems. Maintenance efforts are dominated by FORTRAN with 85% usage, followed by Ada (10%), with the remaining systems implemented in a variety of languages, such as assembler and Pascal. Platforms of systems under maintenance are predominantly mainframes (80%), with the remaining 20% maintained on workstation-based processors.

Based in part on these environmental factors, and on recent plans for changes in this environment, several significant paradigm shifts occurred in the SEL's operation. This has led to changes in three areas:

- Organizational goals
- Operations and development environments
- Resources

Change #1: Organizational Goals

From its inception, the SEL has focused on both increasing software reliability and reducing life cycle costs. Over the past 8 years, the SEL has achieved measured gains in both areas: reliability of delivered systems has increased threefold and current mission support costs are half that of older systems. However, with "time to deploy" pressure increasing, SEL goals now emphasize development time as well as cost. In response to this, the FDD, with the SEL's support, is expanding development of high-reuse, generalized systems to encompass more flight dynamics application areas. The SEL is investigating a variety of joint team development processes as well as cataloguing and assessing existing maintenance processes to identify potential time-savers.

Change #2: Operations and Development Environments

The change here—the transition from mainframes to workstations—has already been discussed. In support of this trend, the SEL provides historical data on completed system rehosting activities for management planning of subsequent efforts. Data collection and measurement activities are also being revisited to determine whether these procedures must be modified. In addition, new computer-aided software engineering (CASE) tools are being investigated for use on the available workstations.

Change #3: Resources

From 1989 through 1994, resources increased by about 10% per year, enabling the SEL to undertake several NASA-wide initiatives: developing guidebooks and assessment reports on specialty topics such as measurement, NASA-wide software characteristics, domain identification, and technology transfer activities. These experience exchanges facilitated the spread of SEL concepts not only throughout NASA, but beyond, to other government organizations and industry. However, resources for 1995 have been significantly reduced, prompting a reevaluation of both internal and external efforts. The SEL has decided to

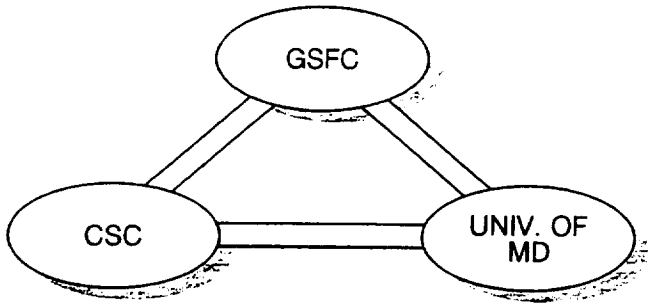
focus external outreach efforts on similar domains within NASA and to investigate new processes likely to provide direct cost benefits in the FDD production environment.

Impact and Observations

Given the above changes, what are the lessons?

- The first experience lesson is that new process technologies must be integrated within the existing process framework. The SEL approach of understanding, assessing, and packaging is effective at instilling large, as well as small, process changes because it yields a fundamental understanding of process and product.
- Next, the move to workstations will create a tighter link between process tools, measurement, and process analysis. This should assist SEL analysts in providing more timely feedback to development groups.
- Last, the importance of understanding software domains has been reemphasized in the SEL's work. An ability to compare and contrast domains is critical for technology transfer and tailoring guidance activities.

SOFTWARE ENGINEERING LABORATORY (SEL)



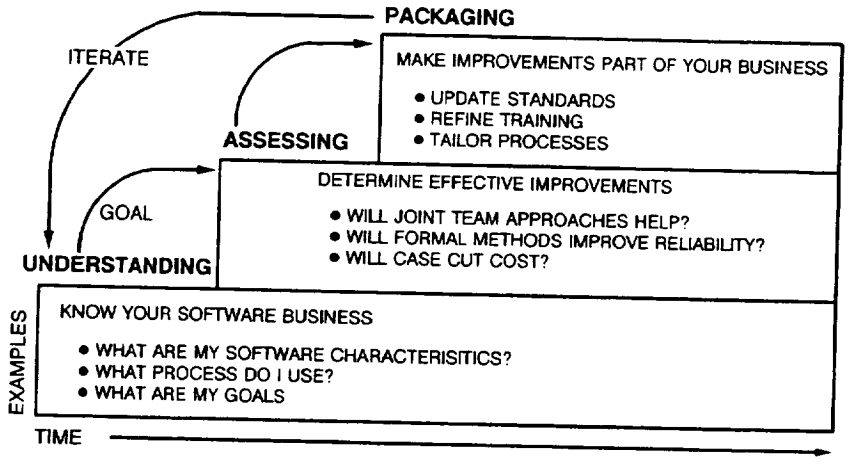
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THE SEL FROM 1976 - 1994

- GOALS
 - UNDERSTAND THE SOFTWARE PROCESS IN A PRODUCTION ENVIRONMENT
 - DETERMINE IMPACT OF AVAILABLE TECHNOLGIES
 - INFUSE IDENTIFIED/REDEFINED METHODS INTO DEVELOPMENT PROCESS
- APPROACH
 - APPLY TECHNOLOGIES AND EXTRACT DETAILED DATA IN PRODUCTION ENVIRONMENT (EXPERIMENT)
 - MEASURE IMPACT (COST, QUALITY, DEVELOPMENT TIME,...)
 - PACKAGE RESULTS (STANDARDS, PROCESSES,TRAINING...)

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SEL PROCESS IMPROVEMENT APPROACH



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SEL PRODUCTION ENVIRONMENT

SOFTWARE CHARACTERISTICS: SCIENTIFIC, GROUND BASED, INTERACTIVE

	DEVELOPMENT	MAINTENANCE
LANGUAGE	70% FORTRAN 15% Ada 15% C	85% FORTRAN 10% Ada 5% OTHER
PROCESSORS	65% MAINFRAME 35% WORKSTATION	80% MAINFRAME 20% WORKSTATION
	PER PROJECT:	PER RELEASE:
DURATION	12-30 MONTHS	3-12 MONTHS
EFFORT	10-25 STAFF YEARS	1-5 STAFF YEARS
SIZE	100K-300K SLOC	WIDE VARIATION

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1994 -- 1995 CHALLENGES

- ORGANIZATIONAL GOALS
- OPERATIONS AND DEVELOPMENT ENVIRONMENTS
- RESOURCES

C649 007

CHANGE #1: ORGANIZATIONAL GOALS

PREVIOUS EMPHASIS ON RELIABILITY & COST ⇨ CURRENT EMPHASIS ON COST & TIME TO DELIVER

- SEL RESPONSE
 - EXPAND OBJECT-ORIENTED, GENERALIZED DEVELOPMENT TO OTHER APPLICATIONS
 - ASSESS JOINT DEVELOPMENT PROCESSES WITHIN CURRENT SEL METHODOLOGY
 - UNDERSTAND MAINTENANCE PROCESS/PRODUCT

INTEGRATE NEW PROCESS TECHNOLOGIES WITHIN EXISTING FRAMEWORK

C649 008

CHANGE #2: OPERATIONS AND DEVLOPMENT ENVIRONMENTS

MAINFRAME APPLICATIONS ⇨ WORKSTATION APPLICATIONS

- SEL RESPONSE
 - PROVIDE MANAGEMENT SUPPORT FOR "REHOST VS NEW" DECISIONS
 - REVISIT MEASURES AND DATA COLLECTION MECHANISMS
 - EXPAND COMPUTER-AIDED SOFTWARE ENGINEERING (CASE) TECHNOLOGY STUDY

POTENTIAL EXISTS FOR GREATER INTEGRATION OF SEL ANALYSIS WITH DEVELOPMENT

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CHANGE #3: RESOURCES

GROWING SUPPORT FOR EXTERNAL OUTREACH (RESOURCES INCREASING) ⇨ FOCUS ON INTERNAL NEEDS (RESOURCES DECREASING)

- SEL RESPONSE
 - USE OUR DETAILED PROCESS UNDERSTANDING TO SELECT TECHNOLOGIES LIKELY TO IMPACT COST
 - CONTINUE DOMAIN IDENTIFICATION EFFORTS TO FIND "LIKE" DOMAINS FOR EXPERIENCE EXCHANGES
 - PROMOTE "SEL-APPROACH" TO GSFC/NASA AREAS (PRIMARY) AND OTHER ORGANIZATIONS

DOMAIN IS A KEY DRIVER FOR SEL EXTERNAL OUTREACH EFFORTS

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